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A BIOLOGICAL ASSESSMENT OF THREE SITES ON
PRAIRIE ELK CREEK:
McCONE COUNTY, MONTANA

Project TMDL-M49

June - July 2003

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A report to

The Montana Department of Environmental Quality
Planning, Prevention and Assistance Division
Helena, Montana
Rebecca Ridenour, Project Officer

by

Wease Bollman
Rhithron Associates, Inc.
Missoula, Montana
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INTRODUCTION

Aquatic invertebrates are aptly applied to bioassessment since they are known to be important indicators of stream ecosystem health (Hynes 1970). Long lives, complex life cycles and limited mobility mean that there is ample time for the benthic community to respond to cumulative effects of environmental perturbations. This report summarizes data collected on June 3 and July 12, 2003 from 3 sites on Prairie Elk Creek, a tributary of the Missouri River in McCone County, Montana. These sites lie within the Northwestern Great Plains ecoregion (Woods et al. 1999).

A multimetric approach to bioassessment such as the one applied in this study uses attributes of the assemblage in an integrated way to measure biotic health. A stream with good biotic health is "...a balanced, integrated, adaptive system having the full range of elements and processes that are expected in the region's natural environment..." (Karr and Chu 1999). The approach designed by Plafkin et al. (1989) and adapted for use in the State of Montana has been defined as "... an array of measures or metrics that individually provide information on diverse biological attributes, and when integrated, provide an overall indication of biological condition" (Barbour et al. 1995). Community attributes that can contribute meaningfully to interpretation of benthic data include assemblage structure, sensitivity of community members to stress or pollution, and functional traits. Each metric component contributes an independent measure of the biotic integrity of a stream site; combining the components into a total score reduces variance and increases precision of the assessment (Fore et al. 1996). Effectiveness of the integrated metrics depends on the applicability of the underlying model, which rests on a foundation of three essential elements (Bollman 1998a). The first of these is an appropriate stratification or classification of stream sites, typically, by ecoregion. Second, metrics must be selected based upon their ability to accurately express biological condition. Third, an adequate assessment of habitat conditions at each site to be studied enhances the interpretation of metric outcomes.

Implicit in the multimetric method and its associated habitat assessment is an assumption of correlative relationships between habitat measures and the biotic metrics, in the absence of water quality impairment. These relationships may vary regionally, requiring an examination of habitat assessment elements and biotic metrics and a test of the presumed relationship between them. Bollman (1998a) has studied the assemblages of the Montana Valleys and Foothill Prairies ecoregion, and has recommended a battery of metrics applicable to the montane ecoregions of western Montana. This metric battery has been shown to be sensitive to impairment, related to measures of habitat integrity, and consistent over replicated samples. Similarly, multimetric bioassessment indices using aquatic invertebrates were developed by Bramblett et al. (2002) for streams of the Plains ecoregions of Montana. These indices were evaluated for responsiveness to anthropogenic disturbances, lack of responsiveness to natural factors, and temporal stability.

In this report, 3 assessment methods are used: first, taxonomic data is translated in to 2 bioassessment indices, and metric scores in each index are summed to derive impairment classifications and use support designations. Second, a narrative interpretation, based on the author's professional judgment is given. Metric performance and taxonomic data are both applied to this analysis. Third, the model of Barbour and Stribling (1991) is applied to bioassessment and habitat assessment scores. While the interdependence of these methods is obvious, since the same data are used for all, some degree of independence is maintained throughout the analysis. Narrative interpretations are given without regard to the bioassessment index result, and without reference to habitat assessment. Since indices are summations, they can often mask evidence of impairment; the narratives attempt to expose the potential shortcomings of the indices. Similarly, graphing the association between habitat assessment scores and bioassessment scores using the model of Barbour and Stribling can provide clues to offer support or possible refutation of the conclusions of the narrative analysis.

METHODS

Samples were collected on June 3 and July 12, 2003 by Montana Department of Environmental Quality (Montana DEQ) personnel. Sample designations and site locations are indicated in Table 1 and on Figure 4. The site selection and sampling method employed were those recommended in the Montana DEQ Standard Operating Procedures for Aquatic Macroinvertebrate Sampling (Bukantis 1998). Aquatic invertebrate samples were delivered to Rhithron Associates, Inc., Missoula, Montana for laboratory and data analyses.

In the laboratory, the Montana DEQ-recommended sorting method was used to obtain subsamples of at least 300 organisms from each sample, when possible. When fewer than 300 organisms occurred in a sample, the entire sample was sorted. Organisms were identified to the lowest possible taxonomic levels consistent with Montana DEQ protocols.

Table 1. Sample designations and locations. Sites are listed in upstream-to-downstream order. Prairie Elk Creek, June – July 2003.

Site ID	Station ID	Activity ID	Location Description	Collection Date	Latitude	Longitude
PE - 1	M49PREKC03	03-L467-M	U/S of Flying V Cr	7/12/03	47° 43' 23"	105° 50' 17"
PE - 2	M49PREKC04	03-L468-M	U/S of Shade Cr	7/12/03	47° 48' 34"	105° 52' 09"
PE - 3	M49PREKC01	03-L440-M	Near Mouth	6/3/03	47° 57' 0.72"	105° 53' 41.28"

Table 2. Provisional metrics and scoring criteria for the Montana Plains ecoregions. (Bukantis, 1998).

METRICS	SCORES			
	3	2	1	0
Taxa richness	>24	24 - 18	18 - 12	<12
EPT richness	>8	8 - 6	5 - 3	<3
Biotic Index	<5	5 - 6	6 - 7	>7
% Dominant taxon	<30	30 - 45	45 - 60	>60
% Collectors	<60	60 - 80	80 - 95	>95
% EPT	>50	50 - 30	30 - 10	<10
Shannon H (log2)	>3.0	3.0 - 2.4	2.4 - 1.8	<1.8
% Scrapers + shredders	>30	30 - 15	15 - 3	<3
# Predator taxa	>5	4 - 5	3 - 4	<3
% Multivoltine	<40	40 - 60	60 - 80	>80

Two bioassessment methods were employed in evaluating the data. First, the metric battery recommended in the Montana DEQ standard operating procedures (Bukantis 1998)

was used. Metrics and scoring criteria for this method are given in Table 2. These metrics should be considered provisional, since correlative relationships between them and meaningful measures of habitat condition and water quality have not been evaluated. Assurance of the validity of associations between meaningful habitat measures and biotic metrics is particularly compelling in the Plains ecoregion, since impairment of the biotic health of streams in this region is generally the result of non-point sources of water quality degradation and habitat disturbance. Agricultural activities, including cattle grazing and flow alteration, are predominant causes of disturbance. The benthic assemblages of the Plains ecoregions, and the performance of these bioassessment metrics have not yet been examined thoroughly enough to determine whether or not the individual metrics or their integrated scores can discriminate impaired conditions from good biotic health. Thus, conclusions concerning bioassessment based upon these metrics must be regarded as tentative. To facilitate scoring, metric values were transformed into a non-dimensional scale. The range of each metric has been divided into four parts and assigned a point score between zero and three. A score of three indicates a metric value similar to one characteristic of a non-impaired condition. A score of zero indicates strong deviation from non-impaired condition and suggests severe degradation of biotic health. Scores for each metric were summed to give an overall score, the total bioassessment score, for each site in each sampling event.

Recently, multimetric bioassessment indices using aquatic invertebrates were developed by Bramblett et al. (2002) for streams of the Plains ecoregions of Montana. Separate indices for riffle sites and pool sites resulted from this study. These indices were evaluated for responsiveness to anthropogenic disturbances, lack of responsiveness to natural factors, and temporal stability. Although the indices probably need further refinement and have not yet been accepted for standard bioassessment use by the State, metric values, scores, and assessments using the appropriate index are given here in Table 5. To allow for comparison with the Montana DEQ standard procedure, Figure 1 compares scores from each method with each Plains stream site.

For both bioassessment methods, total scores were expressed as the percent of the maximum possible score and these were converted into use support classifications. Criteria for use-support designations were developed by Montana DEQ and are presented in Table 3a. Scores were also translated into impairment classifications according to criteria outlined in Table 3b.

Table3a. Criteria for the assignment of use-support classifications / standards violation thresholds (Bukantis 1998).

% Comparability to reference	Use support
>75	Full support--standards not violated
25-75	Partial support--moderate impairment--standards violated
<25	Non-support--severe impairment--standards violated

Table3b. Criteria for the assignment of impairment classifications (Plafkin et al. 1989).

% Comparability to reference	Classification
> 83	nonimpaired
54-79	slightly impaired
21-50	moderately impaired
<17	severely impaired

RESULTS

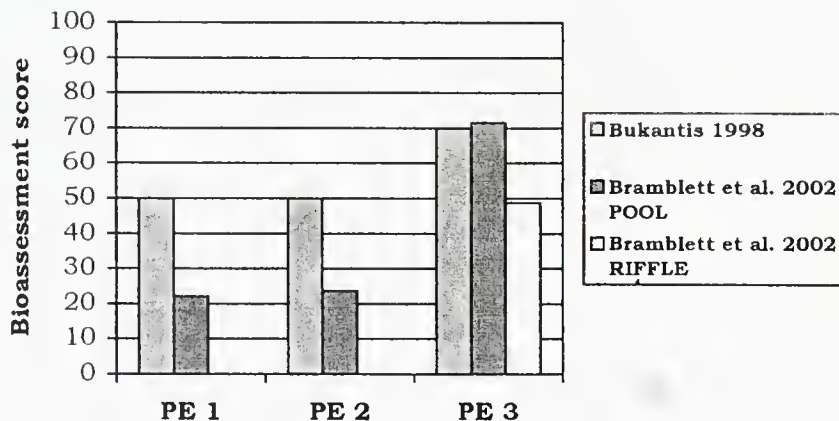
Bioassessment

Table 4 itemizes each metric in the Montana DEQ battery (Bukantis 1998) and shows individual metric scores for each site. Tables 5a and 5b similarly show the metrics and scores for the revised Plains batteries (Bramblett et al. 2002). Figure 1 compares total bioassessment scores for each of the 3 Prairie Elk Creek sites, and also compares the results of the 2 bioassessment methods.

To assess site PE-3 using the revised Plains method (Bramblett et al. 2002), both riffle and pool indices were applied to the data, since the habitat type was not easily determined from the materials provided. Habitat conditions at all 3 sites were evaluated using a method for streams with glide/pool prevalence, and samples at 2 sites (PE-1 and PE-2) were taken with a jab technique. Biota collected at sites PE-1 and PE-2 appear to be representative of lentic environs; it seems obvious that the revised Plains metric battery for pool sites is appropriate for sites PE-1 and PE-2. At site PE-3, however, the sample was taken using a timed kicknet collection, and the assemblage included several rheophilic taxa, indicating that the pool battery may not be suitable for the analysis of these data. As Figure 1 illustrates, notably different total assessment scores resulted from applying the battery devised for riffle sites versus the battery devised for pool sites.

When results from the revised batteries (Bramblett et al. 2002) are compared with results from the Montana DEQ battery (Bukantis 1998), sites were ranked similarly, but total scores differed. The revised batteries suggest that sites PE-1 and PE-2 were moderately impaired and non-supportive of designated uses. When the revised battery was used, scores indicated that these 2 sites were moderately impaired and partly supported uses. Scores calculated for data collected at site PE-3 indicate slight impairment and partial use support when the revised battery for pool sites was used. The revised riffle battery suggests moderate impairment and partial use support at site PE-3.

Figure 1. Comparison of total bioassessment scores (reported as percent of maximum score). the Montana Plains ecoregions reference (Bukantis 1998) was used to calculate scores represented by gray bars, and revised Plains batteries (Bramblett et al. 2002) were used to calculate scores represented by blue bars. Prairie Elk Creek, June - July 2003.



Aquatic invertebrate communities

Interpretations of biotic integrity in this report are made without reference to results of habitat assessments, or any other information about the sites or watersheds that may have accompanied the invertebrate samples. Interpretations are based entirely on: the taxonomic and functional composition of the sampled invertebrate assemblages; the sensitivities, tolerances, physiology, and habitus information for individual taxa gleaned from the writer's research; the published literature, and expert sources; and on the performance of bioassessment metrics, described earlier in the report, which have been demonstrated to be useful tools for interpreting potential implications of benthic invertebrate assemblage composition.

Neither of the upstream sites (PE-1 and PE-2) yielded samples with abundant invertebrates. A depauperate invertebrate fauna in collections, given adequate sampling effort and appropriate sampling locations, can indicate severe water quality and/or habitat disturbances.

Table 4. Bioassessment metrics and scores for 3 sites on Prairie Elk Creek. Site locations are given in Table 1. Montana Plains ecoregions reference (Bukantis 1998).

	SITES		
METRIC VALUES	PE-1	PE-2	PE-3
Taxa richness	19	21	25
EPT richness	0	2	7
Biotic Index	7.68	7.93	6.38
% dominant taxon	32.97	27.47	15.31
% collectors	28.11	63.74	54.07
% EPT	0.00	6.59	31.27
Shannon diversity	1.90	2.66	2.86
% Scrapers + shredders	43.24	7.69	23.13
# Predator taxa	9	6	5
% Multivoltine	72.43	57.14	60.59
METRIC SCORES			
Taxa richness	2	2	3
EPT richness	0	0	2
Biotic Index	0	0	1
% dominant taxon	2	3	3
% collectors	3	2	3
% EPT	0	0	2
Shannon diversity	1	2	2
% Shredders + scrapers	3	1	2
# Predator taxa	3	3	2
% Multivoltine	1	2	1
TOTAL SCORE	15	15	21
PERCENT OF MAXIMUM	50.00	50.00	70.00
IMPAIRMENT CLASSIFICATION¹	MOD	MOD	SLI
USE SUPPORT¹	PART	PART	PART

¹ Impairment classifications: (NON) non-impaired, (SLI) slightly impaired, (MOD) moderately impaired, (SEV) severely impaired. Use support classifications: (FULL) fully supports designated uses, (PART) partially supports designated uses, (NON) non-supportive of designated uses. See Table 3b for impairment classification criteria and Table 3a for use support criteria.

The lack of rheophilic taxa at the upstream sites on Prairie Elk Creek (PE-1 and PE-2) indicates that lentic flow conditions limited the diversity of the invertebrate assemblages in these reaches. The uppermost site (PE-1) supported a very tolerant assemblage; the biotic index value (7.68) was higher than expected. Not a single mayfly was collected here. These findings suggest that water quality may have been degraded by nutrients. Warm water

temperatures likely combined with enrichment to produce hypoxic sediments, which were inhabited by hemoglobin-bearing midges such as *Glyptotendipes* sp. and *Endochironomus* sp. Instream habitats apparently consisted of soft substrates and macrophytes. The functional composition of the sampled assemblage includes a large proportion of shredders, especially the midges in *Cricotopus* (*Isocladius*) spp., suggesting that plant material provided an important energy source for invertebrates here.

Table 5a. Bioassessment metrics and scores for 3 sites on Prairie Elk Creek using the multimetric index developed by Bramblett et al. (2002) for pool sites. Site locations are given in Table 1.

	SITES		
	PE-1	PE-2	PE-3
METRIC VALUES			
Ephemeroptera richness	0	2	1
Trichoptera richness	0	0	7
% EPT	0	6.59	31.27
% non-insect	25.41	36.26	4.89
Filterer richness	1	0	5
Univoltine richness	6	8	10
% supertolerant	44.86	67.03	17.59
METRIC SCORES			
Ephemeroptera richness	0.00	33.33	16.67
Trichoptera richness	0.00	0.00	100.00
% EPT	0.00	19.05	90.38
% non-insect	68.12	54.50	93.86
Filterer richness	25.00	0.00	100.00
Univoltine richness	33.33	44.44	55.56
% supertolerant	28.28	14.77	44.90
TOTAL SCORES (% of maximum)	22.10	23.73	71.62
IMPAIRMENT CLASSIFICATION¹	MOD	MOD	SLI
USE SUPPORT¹	NON	NON	PART

¹ Impairment classifications: (NON) non-impaired, (SLI) slightly impaired, (MOD) moderately impaired, (SEV) severely impaired. Use support classifications: (FULL) fully supports designated uses, (PART) partially supports designated uses, (NON) non-supportive of designated uses. See Table 3b for impairment classification criteria and Table 3a for use support criteria. These criteria were applied even though classifications and criteria have not been established for this index.

Upstream of Shade Creek, site PE-2 yielded a sample with a small number of mayflies in 2 genera: *Callibaetis* sp. and *Caenis* sp. Although the presence of mayflies suggests better water quality here than at site PE-1, the biotic index value (7.93) was higher, indicating a very tolerant group of inhabitants. Thirty-six percent of animals taken in the sample were non-insects. Nutrient enrichment and warm water temperatures were likely; hypoxic sediments

were indicated by a rich hemoglobin-bearing fauna, including *Chironomus* sp. and *Endochironomus* sp. Soft substrates appear to have been a dominant habitat type. Gatherers dominated the functional mix; ostracods constituted the largest proportion of these.

Near its mouth, Prairie Elk Creek at site PE-3 supported a fauna with both lentic and lotic affiliations. Fifteen percent of the animals collected here were rheophilic filter-feeders, including the hydropsychid caddisflies *Cheumatopsyche* sp. and *Hydropsyche* sp. as well as the polycentropodid *Nyctiophylax* sp. Invertebrates were generally more abundant at this site compared to the upstream sites. The biotic index value (6.38) calculated for the assemblage collected here was notably lower than those of the other Prairie Elk Creek sites, suggesting that

Table 5b. Bioassessment metrics and scores for site PE-3 on Prairie Elk Creek using the multimetric index developed by Bramblett et al. (2002) for riffle sites. Site locations are given in Table 1.

	SITE
	PE-3
METRIC VALUES	
EPT richness	7
Percent EPT	31.27
Percent Oligochaetes and Leeches	4.56
Percent 2 dominants	29.32
Filterer richness	5
Percent intolerant	0
Univoltine richness	10
Percent "clingers"	41.69
Swimmer richness	2
METRIC SCORES	
EPT richness	63.64
Percent EPT	38.80
Percent Oligochaetes and Leeches	53.47
Percent 2 dominants	62.36
Filterer richness	83.33
Percent intolerant	0.00
Univoltine richness	58.82
Percent "clingers"	50.05
Swimmer richness	28.57
TOTAL SCORES (% of maximum)	48.78
IMPAIRMENT CLASSIFICATION¹	MOD
USE SUPPORT¹	PART

¹ Impairment classifications: (NON) non-impaired, (SLI) slightly impaired, (MOD) moderately impaired, (SEV) severely impaired. Use support classifications: (FULL) fully supports designated uses, (PART) partially supports designated uses, (NON) non-supportive of designated uses. See Table 3b for impairment classification criteria and Table 3a for use support criteria. These criteria were applied even though classifications and criteria have not been established for this index.

enrichment and/or elevated temperatures may have been less influential here. Instream habitats may have been relatively complex here. The midge *Pseudochironomus* sp. was abundant; sandy sediments are implied. Stony substrates were also indicated; the hydropsychid caddisflies and the hydroptilid *Ithytrichia* sp. are associated with these features.

Macrophytes appear to have been present; the elmid *Dubiraphia* sp. and the hydroptilid caddisfly *Hydroptila* sp. were collected. The functional composition of the sample included diverse elements appropriate to a Plains site.

CONCLUSIONS

- Lentic flow conditions, warm water temperatures, nutrient enrichment, and simple habitats apparently limit the integrity of invertebrate assemblages at the 2 upstream sites on Prairie Elk Creek (PE-1 and PE-2).
- Better water quality and more complex instream habitats could be detected in the taxonomic and functional composition of the assemblage collected at site PE-3.

Habitat assessment

Figure 2 graphically compares total habitat assessment scores recorded for the 3 sites in this study. Table 6 shows the habitat parameters evaluated, parameter scores and overall habitat evaluations for the sites studied.

Figure 2. Total habitat assessment scores for Prairie Elk Creek sites. June - July 2003.

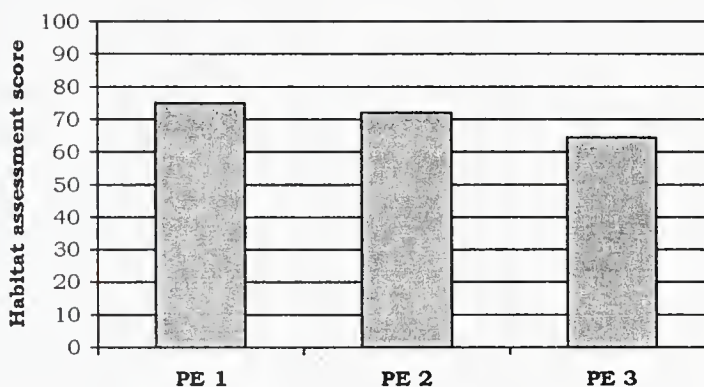


Table 6. Stream and riparian habitat assessment. Prairie Elk Creek sites were assessed based upon criteria developed by Montana DEQ for streams with glide/pool prevalence. June - July 2003.

Max. possible score	Parameter	SITES		
		PE-1	PE-2	PE-3
20	Bottom substrate	16	10	10
20	Pool substrate char.	15	9	13
20	Pool variability	16	11	17
20	Channel alteration	19	20	15
20	Sediment deposition	16	16	16
20	Channel sinuosity	18	20	12
20	Channel flow status	18	18	16
20	Bank vegetation	8 / 6	9 / 9	6 / 6
20	Bank stability	7 / 5	9 / 9	6 / 6
20	Vegetated zone	4 / 2	4 / 4	3 / 3
200	Total	150	144	129
	Percent of maximum	75%	72%	64.5%
	CONDITION*	sub-optimal	sub-optimal	sub-optimal

* Condition categories: Optimal > 80% of maximum score; Sub-optimal 75 - 56%; Marginal 49 - 29%; Poor <23%. Plafkin et al. 1989.

Overall habitat conditions at all 3 sampled sites on Prairie Elk Creek were judged sub-optimal. At site PE-1 (upstream of Flying V Creek), most instream habitat parameters and channel features were perceived to be optimal. Streambanks were assessed as moderately stable to moderately unstable, and the riparian zone was noted to be abbreviated. Instream habitat was judged marginal at the site upstream of Shade Creek (PE-2). Channel elements were thought to be in optimal condition, and streambanks were perceived to be stable. Riparian zone width, however, was limited here. Marginal substrate variety was assessed at site PE-3, near the mouth of Prairie Elk Creek. Channel morphology was rated optimal to suboptimal, and streambanks were judged moderately stable. Abbreviated riparian zone width was again noted.

Habitat assessment vs. bioassessment

When habitat assessment scores are plotted against bioassessment scores, the resulting figure provides an opportunity to evaluate the hypothetical relationship between habitat integrity and water quality. Both factors are critical and interactive determinants of the composition and functional integrity of aquatic invertebrate assemblages. Presumably, high quality habitat, in the absence of impairments to water quality, supports functional, diverse, and sensitive invertebrate assemblages; these are assemblages that attain high bioassessment scores. Barbour and Stribling (1991) have hypothesized that diminishing habitat quality should produce predictable diminishment of bioassessment scores, when water quality is not a further insult. Figure 3 is a plot of habitat assessment scores against bioassessment scores for the sampled assemblages of Prairie Elk Creek. The red line superimposed on the plot represents the hypothetical relationship between habitat quality and biotic integrity given good water quality. In this model, symbols falling in the upper right area of the graph would represent sites with high scores for both bioassessment and habitat assessment; according to this model, these would be unimpaired sites both in terms of habitat integrity as well as water quality. Some degree of habitat degradation is hypothesized for sites located along the downward

progression of the red line, that is, when bioassessment scores are falling predictably with decreasing habitat scores. When habitat scores remain high, but bioassessment scores are inordinately low, sites fall into the lower right hand quadrant of the plot. According to the model, these sites support invertebrate assemblages that are impacted mostly by impairment to water quality. Symbols near the red line are sites where habitat degradation outweighs water quality perturbation in determining the integrity of biotic assemblages. The plot in Figure 3 suggests that Prairie Elk Creek invertebrates at sites PE-1 and PE-2 are influenced mostly by water quality degradation. Site PE-3 appears to be influenced more by habitat degradation as is indicated by the fact that it is closer to the red line.

Figure 3. Total bioassessment scores plotted against habitat assessment scores for sites on Prairie Elk Creek. June - July 2003. (Barbour and Stribling 1991).

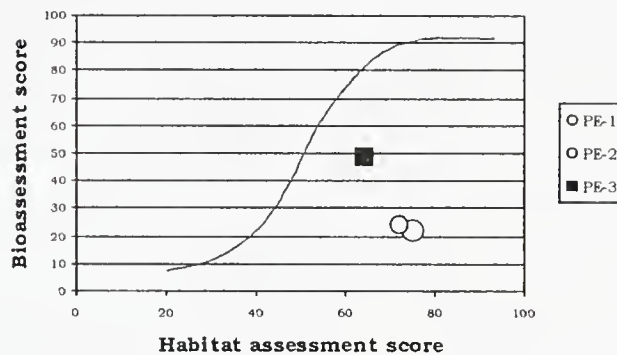




Figure 4. Approximate sampling locations on Prairie Elk Creek. June - July 2003.

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